

CPE/EE 322
Engineering Design VI
Lesson 4: Structuring the Search for
a Solution

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Outline

1. The need to structure the search for a solution
2. Designing the search strategy
3. Subdividing the problem into design goals
4. Working within quantitative constraints: design specifications
5. Ergonomic constraints in design

Objectives

G. Voland, Engineering by Design, Chapter 4

- Explain the need to properly structure the search for a solution to a problem
- Design each task in a problem-solving effort so that it is most fruitful and provides the most information or guidance
- Use various attributes of the final solution state to guide earlier decisions made along the solution path
- Define the most common or general engineering design goals
- Differentiate between general and specific design goals
- Differentiate between design goals and design specifications
- Eliminate paths that do not satisfy the desired design goals and/or specifications
- Use anthropometric, anatomical, physiological, and other types of ergonomic data to formulate design goals and constraints for human-machine systems

Lab 4 — Django and Flask

- Study the GitHub [repository](#) Lesson 4 labs
- Install [Django](#) and Django [REST](#) framework
- Use the default database, i.e., [SQLite](#)
- Start Django project "stevens," run server, and view app
- Start Django REST project "mycpu," run server, and view app
- Install [Flask](#) if no module named 'flask'
- Run Flask server via `hello_world.py` and view app

Assignment 4 — Solution Development

- Design each task in a problem-solving effort so that it is most fruitful and provides the most information or guidance
- Use various attributes of the final solution state to guide earlier decisions made along the solution path
- Define design goals and design specifications
- Eliminate paths that do not satisfy the desired design goals and/or specifications

Program Outcome 2: (Design)

2.3 (Technical design) Students will be able to adjust the overall design of a project by changing or adding a component, developing a representation of the initial understanding of the project design and evolving it to a detailed representation that establishes a "design, test, and build" process based on inputs, outputs, and variables defined by successive levels (hierarchical) of components and subsystems.

The Need to Structure the Search for a Solution

- Brute-force search (or exhaustive search) for possible solutions is not practical because of the limitations on the amount of time, effort, and money that can be invested in a project
- Engineers always work within specific deadlines and search for solutions that lie within rigid constraints
- To design and develop solutions in a timely manner, one can
 - Evaluate both the current problem state and the desired final solution state
 - Develop a strategy for successfully traversing the path from the problem state to the solution state

Designing the Search Strategy

- Eliminating impossible (or unpromising) solution paths
- Design data-collection and information-gathering efforts so that the most useful information can be extracted to formulate the initial situation or problem state to be corrected
- Evaluate the final solution state by identifying the desirable elements, i.e., functional capabilities or characteristics that should be part of any solution
- Select intermediate steps along the path from the problem state to the final solution state, and develop the desired solution by following this path

Subdividing the Problem Into Design Goals

- General design goals
 - Safety
 - Environmental protection
 - Public acceptance
 - Reliability
 - Performance
 - Ease of operation or operating conditions
 - Durability
 - Use of standard parts
 - Minimum cost
 - Minimum maintenance and ease of maintenance
- Specific design goals
- Continuously re-evaluating the goal list

Sustainable Development Goals

<https://sustainabledevelopment.un.org>

1 NO
POVERTY



2 ZERO
HUNGER



3 GOOD HEALTH
AND WELL-BEING



4 QUALITY
EDUCATION



5 GENDER
EQUALITY



6 CLEAN WATER
AND SANITATION



7 AFFORDABLE AND
CLEAN ENERGY



8 DECENT WORK AND
ECONOMIC GROWTH



9 INDUSTRY, INNOVATION
AND INFRASTRUCTURE



10 REDUCED
INEQUALITIES



11 SUSTAINABLE CITIES
AND COMMUNITIES



12 RESPONSIBLE
CONSUMPTION
AND PRODUCTION



13 CLIMATE
ACTION



14 LIFE
BELOW WATER



15 LIFE
ON LAND



16 PEACE, JUSTICE
AND STRONG
INSTITUTIONS



17 PARTNERSHIPS
FOR THE GOALS



ESG

- ESG or Environmental, Social, and (Corporate) Governance refers to the three central factors in measuring the sustainability and societal impact of an investment in a company or business
- These criteria help determine the future financial performance of companies such as return and risk
- Asset managers and other financial institutions increasingly rely on ESG ratings agencies to assess, measure and compare companies' ESG performance, e.g., Refinitiv, S&P Trucost, RobecoSam, Sustainalytics, ISS ESG, MSCI ESG, Vigeo Eiris, EcoVadis, Minerva Analytics
- More recently, data providers have applied artificial intelligence to rate companies and their commitment to ESG
- Each rating agency uses its own set of metrics to measure the level of ESG compliance and there is, at present, no industry-wide set of common standards

One-for-One Business Model

- One for one (also known as "buy-one give-one") is a social entrepreneurship business model reputedly developed by Blake Mycoskie of TOMS Shoes, in which one needed item is given away for each item purchased
 - "The One-for-One Business Model: Avoiding Unintended Consequences," Knowledge@Wharton, February 16, 2015
 - D. Hessekiel, "The Rise and Fall of the Buy-One-Give-One Model at TOMS," Forbes, April 28, 2021
- For every vegan snack bar Two Degrees Food sells, the company donates a meal to a hungry child in need
- For each pair of glasses purchased, Warby Parker pays for the production of another pair of eyeglasses for the nonprofit organization VisionSpring
- Similar businesses include KNO Clothing, Nouri Bar, Roma Boots, Sir Richard's, Soapbox Soaps, etc.

Use Cases

- A [use case](#) is a list of actions or event steps typically defining the interactions between a role (known in the [Unified Modeling Language](#) or UML as an actor) and a system to achieve a goal
- The actor can be a human or other external system
- In systems engineering, use cases often representing missions or [stakeholder](#) goals are used at a higher level than within software engineering that a use case is often used in the plural to suggest situations where a piece of software may be useful
- A [requirement](#) is a singular documented physical or functional need that a particular design, product, or process aims to satisfy
- The detailed requirements may then be captured in the [Systems Modeling Language](#) (SysML) or as contractual statements

Requirement Management

- [Requirements management](#) is a continuous process throughout a project for documenting, analyzing, tracing, prioritizing, and agreeing on requirements and then controlling change and communicating to relevant stakeholders
- [Rational DOORS](#) (Dynamic Object Oriented Requirements System) requirement management tool is a client-server application with its own programming language called [DOORS Extension Language](#) (DXL), a Windows-only client, a web client called DOORS Web Access, and servers for Linux, Windows, and [Solaris](#)
- IBM acquired [Rational Software](#) in 2003
- DOORS is now developed on the IBM [Jazz](#) platform that uses [Open Services for Lifecycle Collaboration](#) (OSLC)

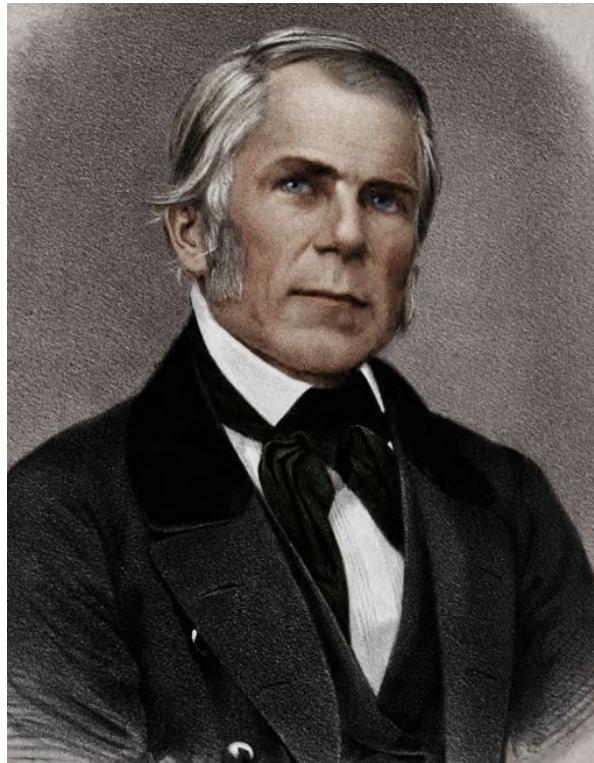
Working Within Quantitative Constraints: Design Specifications

- Identify the constraints or specifications (specs) associated with each design goal
- Specs may be of several different types
 - Physical
 - Functional or operational
 - Environmental
 - Economic
 - Legal
 - Human factors/ergonomics

Ergonomic Constraints in Design

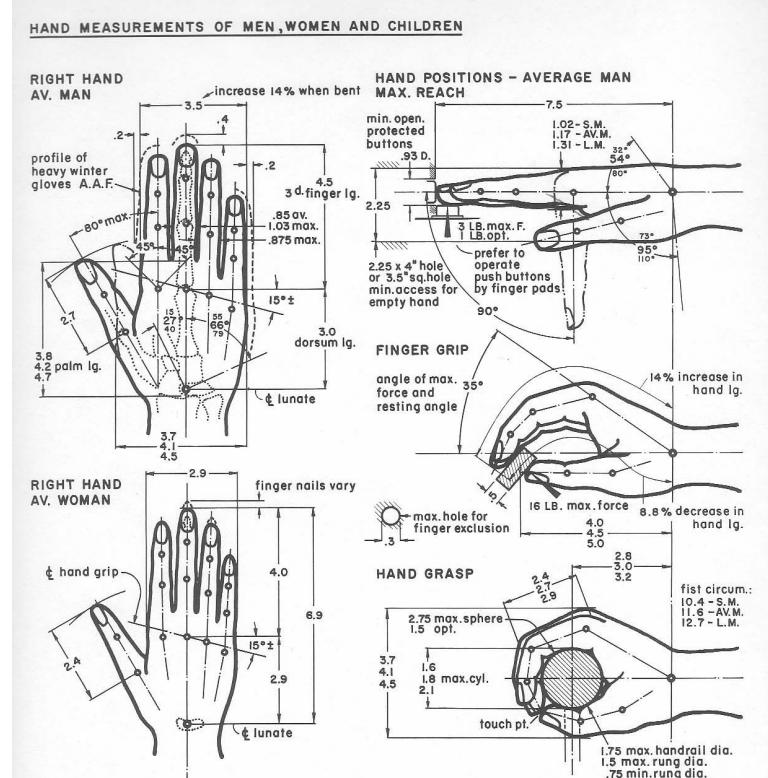
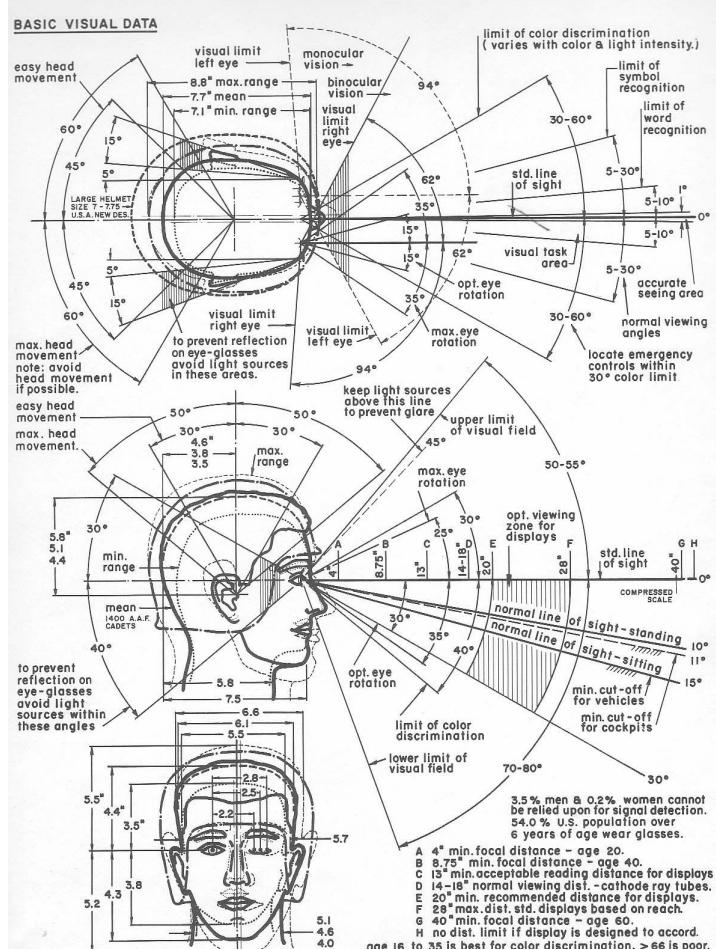
- Human factors engineering or [ergonomics](#) focuses on the variations that exist among different human populations and the effect of these variations on product design decisions
- User characteristics that may be important to the success of an engineering design
 - Visual acuity
 - Hearing discrimination
 - Hand-eye coordination
 - Reaction time
 - Sensitivity to temperature, dust, and humidity
 - Reading skills

Wojciech Jastrzębowski 1799–1882



Polish scientist [Wojciech Jastrzębowski](#) used the word ergonomics in his 1857 article "Rys ergonomicji czyli nauki o pracy, opartej na prawdach poczerpniętych z Nauki Przyrody" (The outline of ergonomics that is science of work, based on the truths taken from the natural science)

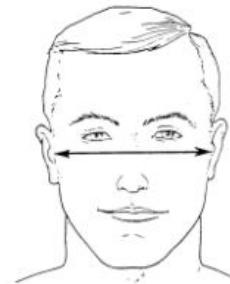
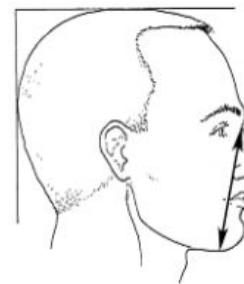
Ergonomic Data Examples



HAND DATA	MEN			WOMEN			CHILDREN			
	2.5%tile	50%tile	97.5%tile	2.5%tile	50%tile	97.5%tile	6 yr.	8 yr.	11 yr.	14 yr.
hand length	6.8	7.5	8.2	6.2	6.9	7.5	5.1	5.6	6.3	7.0
hand breadth	3.2	3.5	3.8	2.6	2.9	3.1	2.3	2.5	2.8	—
3d. finger lg.	4.0	4.5	5.0	3.6	4.0	4.4	2.9	3.2	3.5	4.0
dorsum lg.	2.8	3.0	3.2	2.6	2.9	3.1	2.2	2.4	2.8	3.0
thumb length	2.4	2.7	3.0	2.2	2.4	2.6	1.8	2.0	2.2	2.4

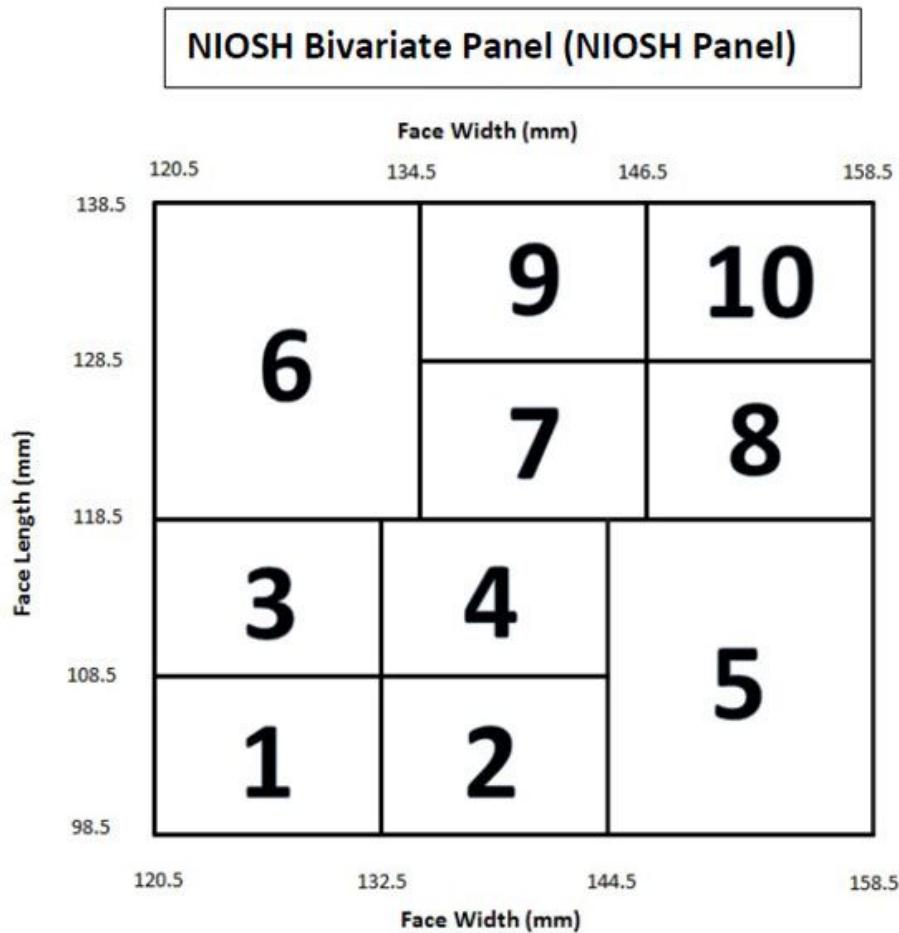
Anthropometric Measurements

[NIOSH Conformity Assessment Interpretation Notice](#)

Description	Definition	Diagram
Bizygomatic Breadth	Maximum horizontal breadth of the face as measured with a spreading caliper between the zygomatic arches.	
Menton-Sellion Length	Distance as measured with a sliding caliper in the midsagittal plane between the menton landmark and the sellion landmark.	

Respirator Sizing and Fit Testing

NIOSH Conformity Assessment Interpretation Notice



Cell Number	Distribution (%)
1	5.5
2	5.3
3	10.5
4	25.0
5	7.1
6	5.7
7	21.3
8	8.7
9	5.2
10	3.5

Developing Human-Machine Interface

- Identify the expected interactions between the user and the product during its operation
- Identify the operations that will require monitoring or control by the user
 - Recognize the limitations of the expected users in performing such tasks
- Evaluate the expected environment in which the product will be used
 - Consider factors such as intensity of light, availability of space, background noise, temperature range, dust levels, humidity values, and vibration levels
- Identify those operations that can be automated or made easier to perform manually
 - Consider the amount of training and experience required by the user to perform the task properly

Lesson 4 Summary

- Formulate the desired characteristics or design goals, recognize the constraints within which any solution must lie, and eliminate those paths that will not satisfy these goals and constraints
- Design goals are qualitative, whereas design specifications (specs) are quantitative
- General goals sought in most engineering design solutions include safety, reliability, performance, ease of operation, minimum cost, *etc.*
- Specific goals that help define the characteristics and desired functions of a particular design include lightweight, water-resistant, transparent, *etc.*
- Use anthropometric, anatomical, physiological, and other types of ergonomic data and principles to formulate certain types of design specs and to optimize interactions between the design and its users

Searching Design Ideas

[TED](#) (Technology, Entertainment, Design) is a media organization that posts [TED Talks](#) online for free distribution under the slogan "ideas worth spreading"



Writing in Space

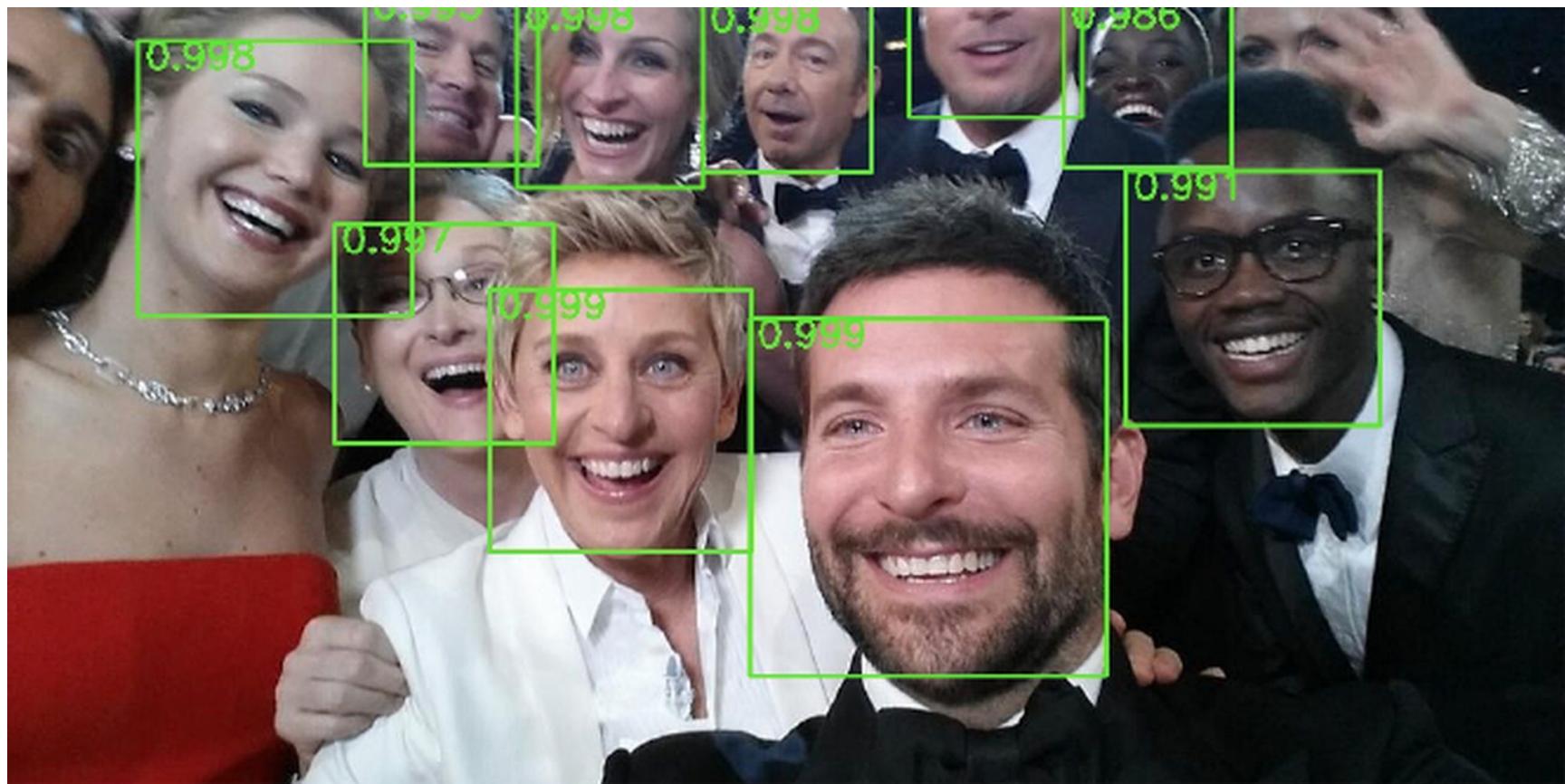
https://en.wikipedia.org/wiki/Writing_in_space

- Pencils made of combustible materials such as wood, graphite, or rubber can create dust—in particular, graphite dust conducts electricity
- Ballpoint or felt-tip pens are subject to outgassing and variations in pressure and temperature depending on the ink composition and viscosity
- The [Fisher Space Pen](#) is a gas-charged ballpoint pen that is rugged and works in a wide variety of conditions such as zero gravity, vacuum, and extreme temperatures
 - Its [thixotropic](#) ink and vent-free cartridge release no significant vapor at common temperatures and low pressures
 - The ink is forced out by compressed nitrogen at a pressure of nearly 35 psi (240 kPa), and it functions at altitudes up to 12,500 feet (3800 m) and at temperatures from −30 to 250 °F (−35 to 120 °C)



Attendance Tracking

[2014 Oscars Selfie, Face Detection Algorithm](#)



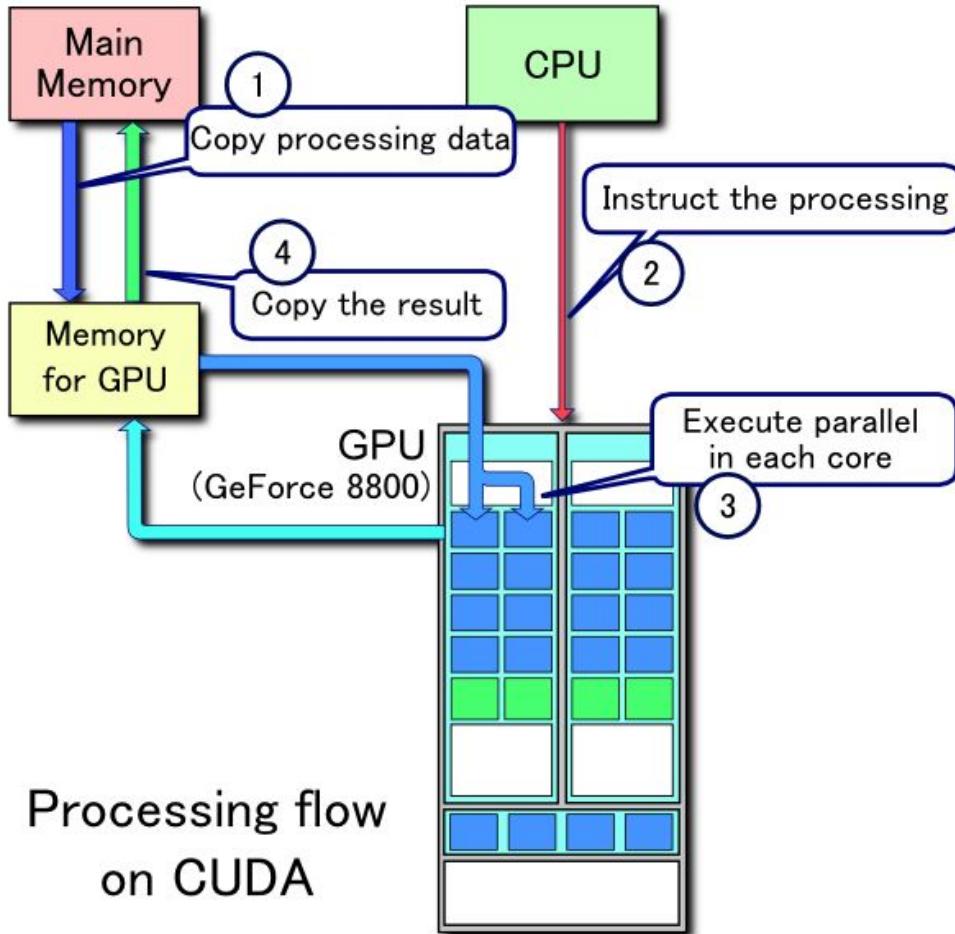
See Through the Hood

Range Rover Evoque [ClearSight Ground View](#)

At speeds up to 30 km/h (18 mph), forward-facing cameras mounted on the side mirrors and front grille deliver a 180° view of the front wheels and the ground beneath and ahead of the vehicle that is typically obscured by the hood

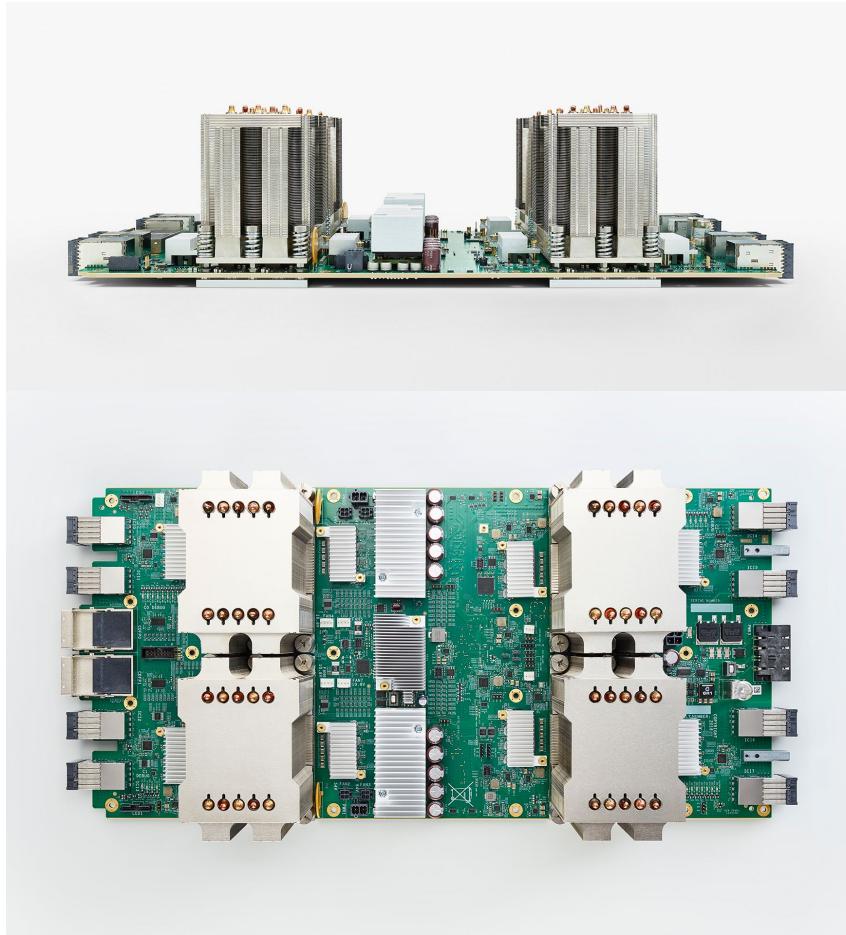


CUDA Processing Flow



- Compute Unified Device Architecture ([CUDA](#)) is a parallel computing platform and application programming interface ([API](#)) model created by Nvidia
- The CUDA platform is a software layer that gives direct access to the virtual instruction set and parallel computational elements of the graphics processing unit ([GPU](#)), for the execution of compute kernels

Tensor Processing Unit (TPU)



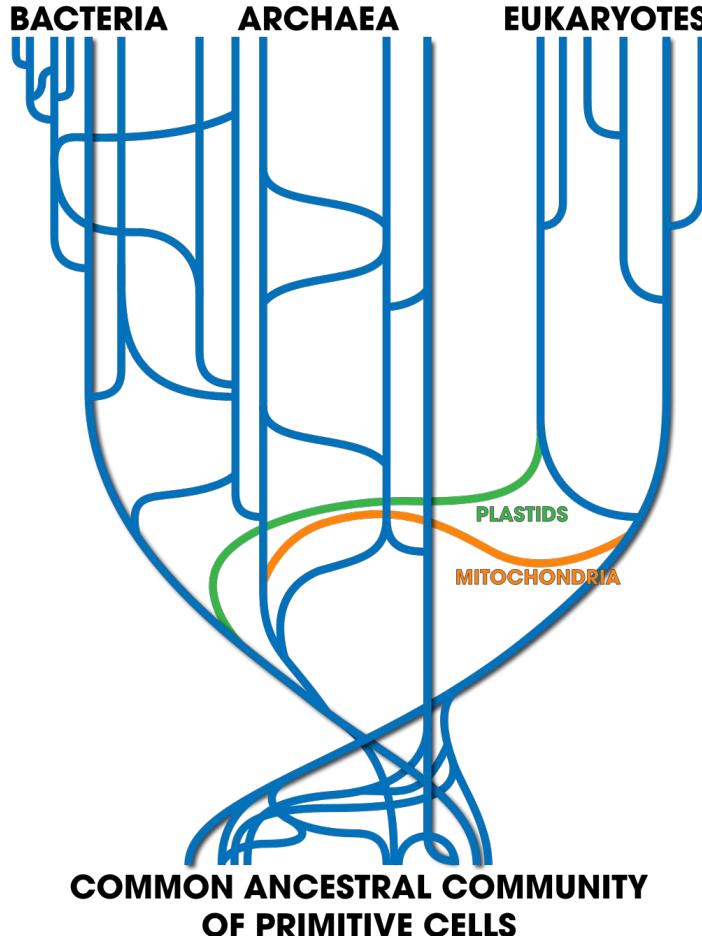
- A [tensor](#) processing unit ([TPU](#)) mounted in a heat sink assembly is an application-specific integrated circuit ([ASIC](#)) developed by Google for machine learning:
 - [TensorFlow](#)
 - [AlphaGo](#)
 - Street View text processing
 - Google Photos
 - [RankBrain](#)
- Compared to a graphics processing unit ([GPU](#)), TPU is designed explicitly for a higher volume of reduced precision computation with higher input/output operations per second ([IOPS](#)) per watt

Life 3.0

In his [book](#), Prof. [Max Tegmark](#) of MIT and cofounder of the Future Life Institute ([FLI](#)) argues that we shouldn't passively ask "what will happen?" as if the future is predetermined (or undirected), but instead ask what we want to happen and then try to create that future (i.e., beneficial intelligence)

Life	Stage	Hardware	Software
1.0	Biological	Evolve	Evolve
2.0	Cultural	Evolve	Design
3.0	Technological	Design	Design

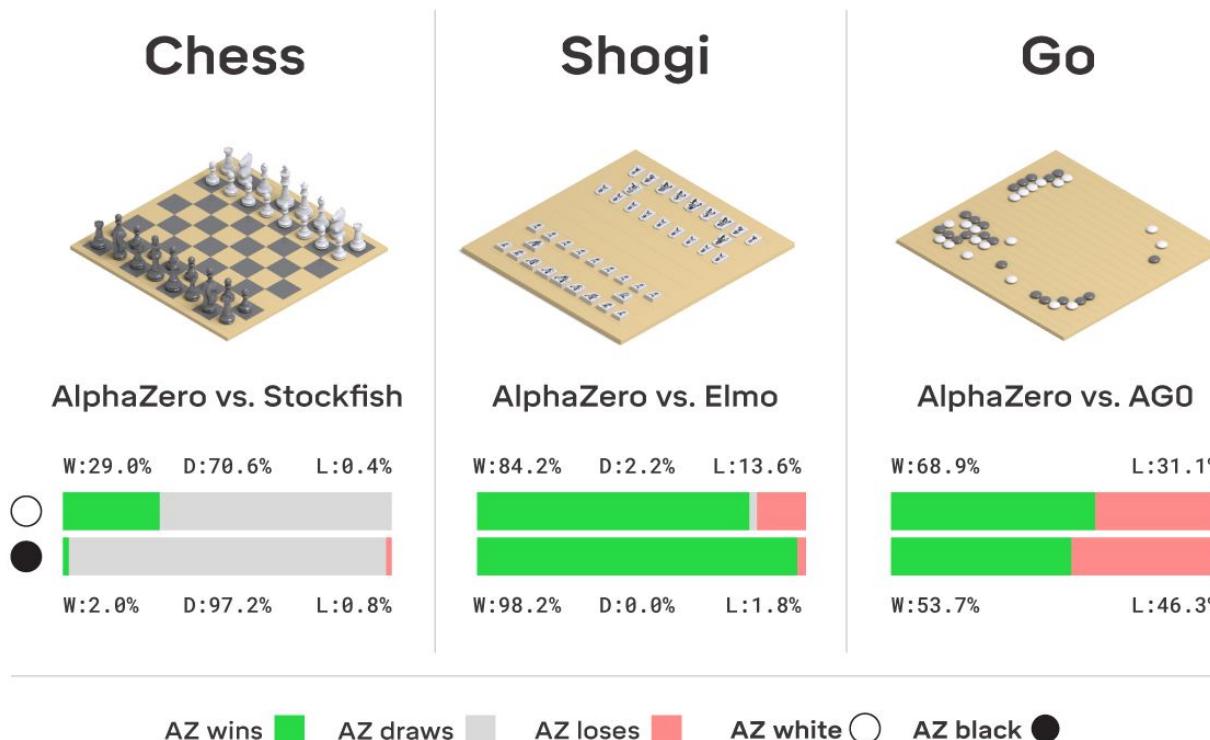
Tree of Life



- The [tree of life](#) refers to the compilation of comprehensive [phylogenetic](#) databases rooted at the last universal common ancestor ([LUCA](#)) of life on earth
- The [three-domain system](#) divides cellular life forms into [Archaea](#), [Bacteria](#), and [Eukaryota](#)
 - [Eukaryotes](#) are organisms whose cells have a nucleus enclosed within membranes
 - [Prokaryotes](#) (Bacteria and Archaea) have no membrane-bound [organelles](#)
- Vertical gene transfer and horizontal gene transfer ([HGT](#)) lead to an interconnected network rather than a plain hierarchy
- The [Open Tree of Life](#) is a project for free public access: <http://opentreeoflife.org>

AlphaGo Zero to AlphaZero

Removing the [Go](#) knowledge from the Go engine made a better Go engine and, at the same time, an engine that could play shogi and chess [[Wikipedia](#), [DeepMind Blog](#)]



Questions About Consciousness

Problem	<u>Tekmark</u> : Consciousness = Subjective experience	
Really hard	Why is anything conscious?	Theories untestable?
Even harder	How do physical properties determine <u>qualia</u> ?	Theories partially testable?
Pretty hard	What physical properties distinguish conscious and unconscious systems?	Theories testable with brain-reading!
Easy	How does the brain process information? How does intelligence work?	Theories testable by simulation

Cold Chain and Retail Shelving



- Milk is one of the most popular items but is often in the back of the grocery store, far from the entrance
- One common explanation is that the back of the store is next to the loading dock for maintaining the final leg of cold chain
- The other explanation is that by forcing customers to walk through the whole store, they will pass more products and end up buying more
- Thomas Blischok examined 1.2 million market baskets in 25 Oscos Drugs stores in 1992 identifying over 20 different product correlations such as beer and diapers in transactions between 5 p.m. and 7 p.m.

Online Supermarket

[Ocado](#)



No Checkout Lines

[Amazon Go](#)



Amazon Logo

History of the Amazon Logo Design Evolution

- Amazon was founded by Jeff Bezos in Bellevue, Washington, on July 5, 1994
- The initial Amazon logo design in 1995 has undergone through significant changes in 1997, 1998, 2000, and 2012 by Turner Duckworth, a division of Leo Burnett Worldwide that is an advertising company founded in 1935 and acquired by Publicis Groupe in 2002
 - Providing customers with everything from a to z
 - Delivering smiles to the doors of the customers



AMAZON.COM

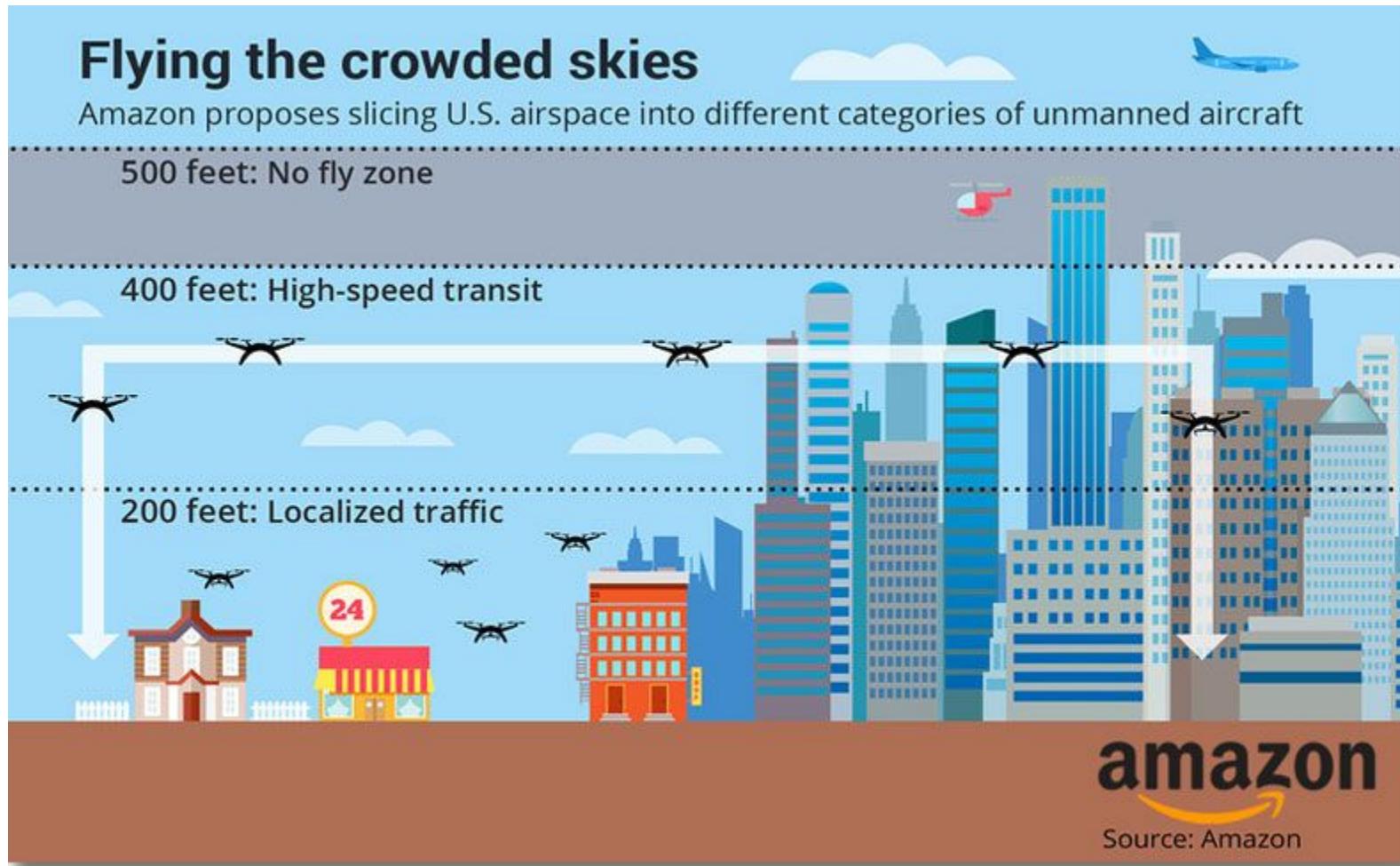
amazon.com

amazon.com®
and you're done.™

amazon

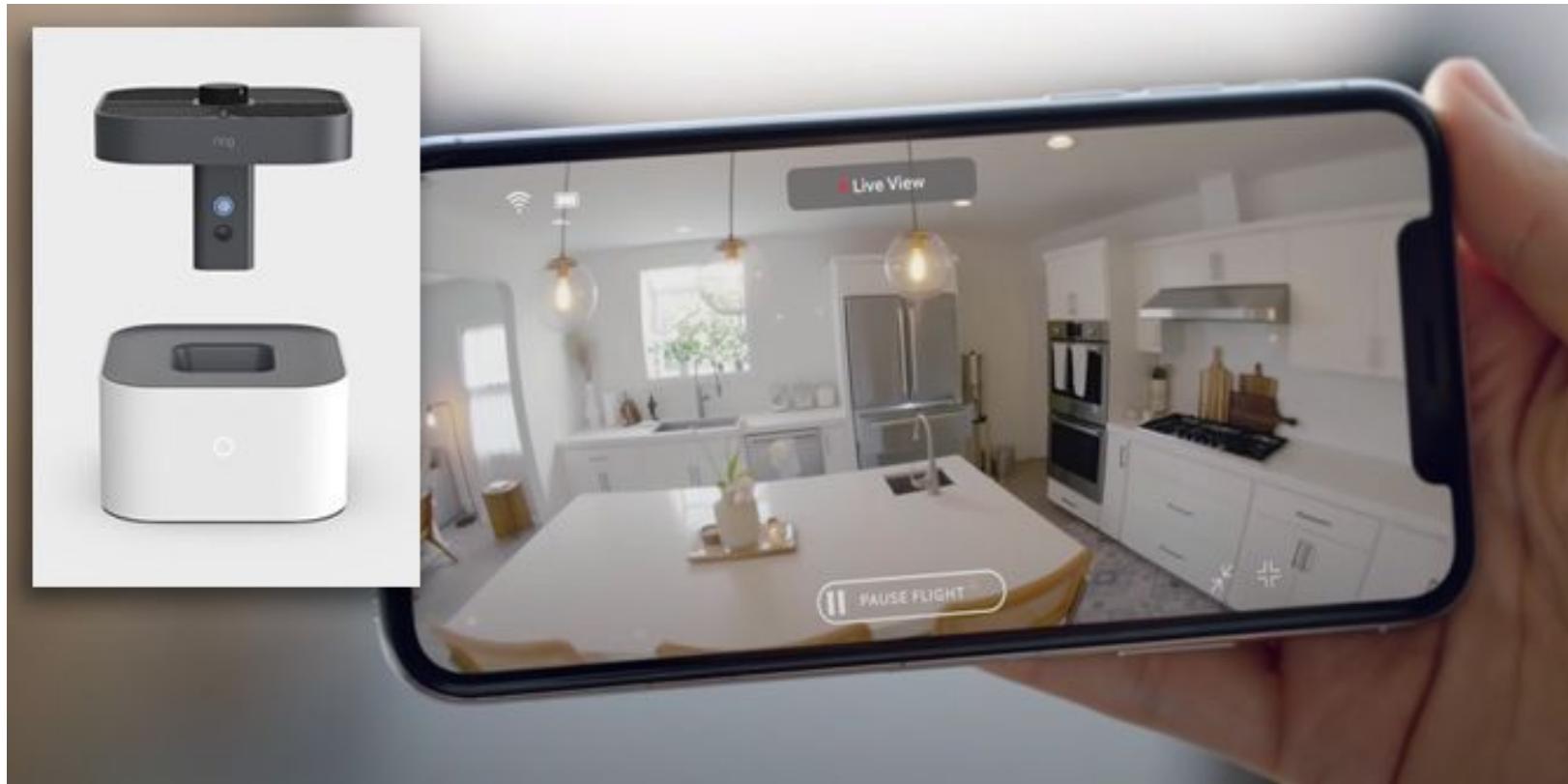
Unmanned Aircraft System (UAS)

<https://www.faa.gov/uas>



Always Home Cam

Ring



Self-Flying Camera

[Skydio](#)



Helicopter Noise Reduction

https://en.wikipedia.org/wiki/Helicopter_noise_reduction

Attack Helicopter

[AH-64 Apache](#) 1975—present

Four evenly spaced blades

Reconnaissance & Attack Helicopter

[RAH-66 Comanche](#) 1996—2004

Five unevenly spaced blades



Cocktail Party Problem

- Edward Colin Cherry 1914—1979 first defined and named the cocktail party problem in 1953 when air traffic controllers must separate the intermixed voices of many pilots over a single loudspeaker—just as a partygoer needs to focus on a single conversation in a noisy room
- In early selection attention models, very little information is processed before selection occurs
- In late selection attention models, more information, like semantics, is processed before selection occurs
- The perceptual load theory created by Nilli Lavie demonstrates that early selection occurs in high load condition and late selection occurs in low load condition

Internet for Rural, Remote Areas

[Loon](#) 2011—2021 provided high-altitude balloons traveling in the stratosphere, designed to create wireless networks that extend internet connectivity to people in rural and remote areas



[Facebook Aquila](#) 2016—2018 was a solar-powered, high-altitude aircraft stay airborne for up to 90 days at a time and beam broadband coverage to a 60-mile-wide area on the ground



Planet Monitoring

[Planet Labs](#) provides frequent, broad-coverage imagery through the [Planet Platform](#)



Glow Sticks

ONE-TIME GLOW STICK



REUSABLE GLOW STICK



- Traditional break-and-shake glow sticks use a chemical reaction that can only happen one time, providing an instant bright light for several hours at the same intensity
- Whereas the reusable glow sticks use enhanced glow-in-the-dark crystal that absorbs light to charge, glow in the dark over 12 hours at a diminishing rate, and can be reused

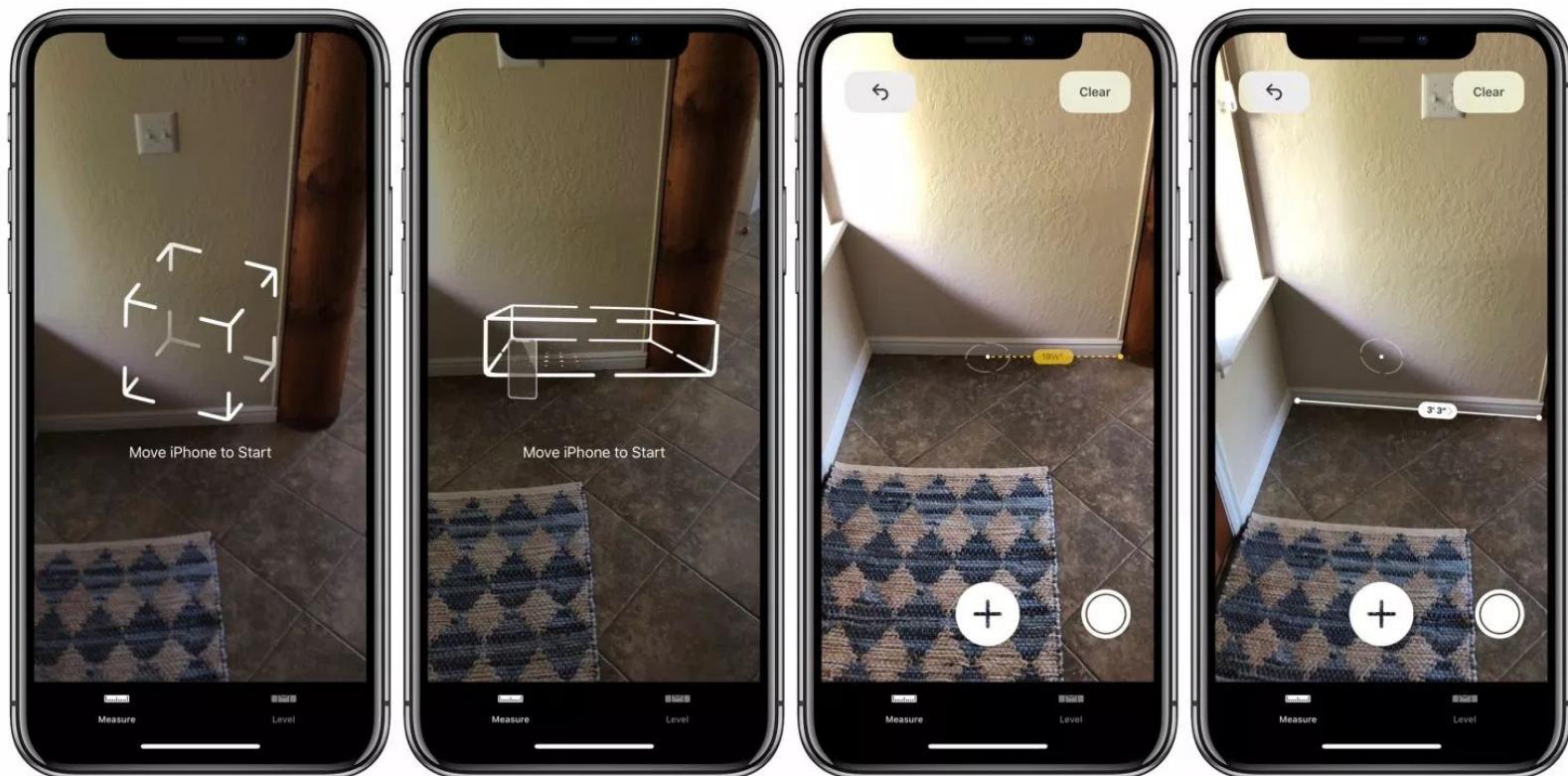
3D Imager

Walabot



Measure App

[Apple ARKit, How to use the Measure app](#)



Mixed Reality

Mixed reality (MR) is a mix of reality and virtual reality (VR), encompassing both augmented reality (AR) and augmented virtuality via immersive technology



Brain-Computer Interface (BCI)

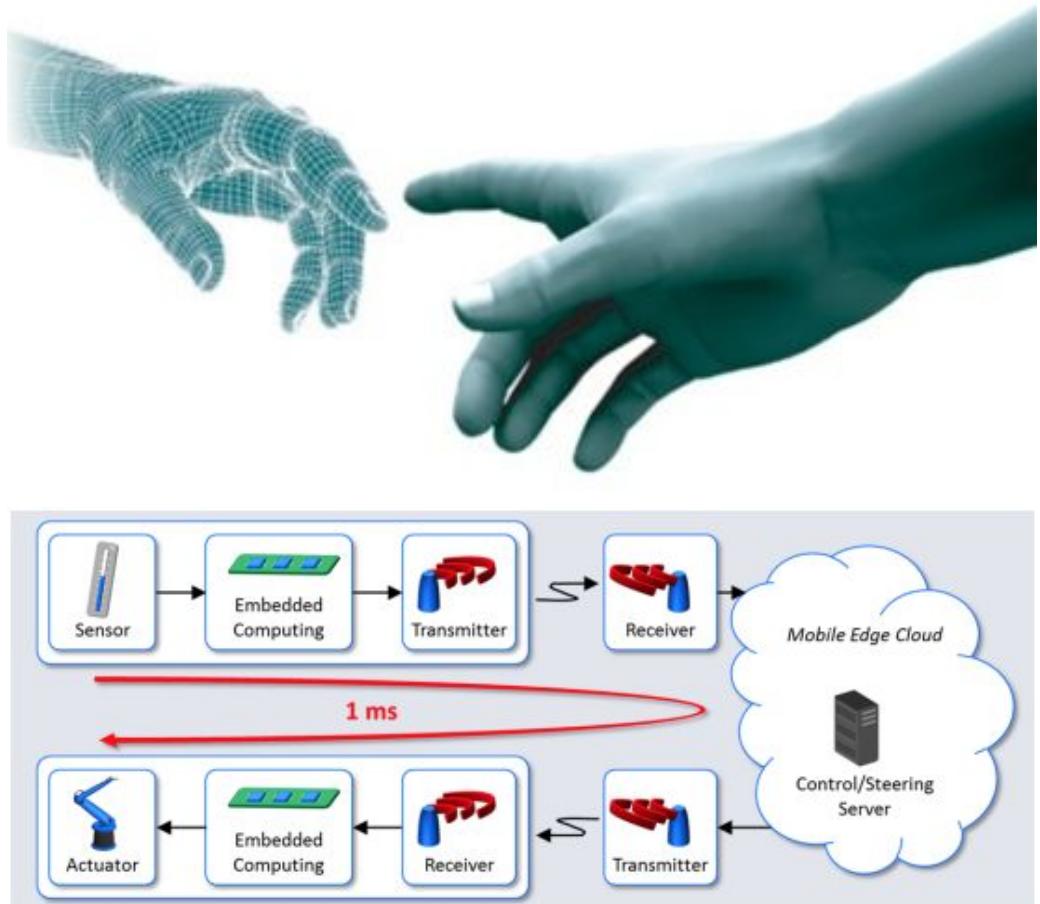


- [Hans Berger](#) 1873–1941 was a German psychiatrist and inventor of electroencephalography ([EEG](#)), an electrophysiological monitoring method to record electrical activity of the brain in 1924
- [Jacques Vidal](#) described the Brain Computer Interface ([BCI](#)) project in his 1973 [paper](#), "Toward direct brain-computer communication," *Annual Review of Biophysics and Bioengineering*, 2 (1), pp. 157–80
- [EMOTIV](#), [mindBEAGLE](#), [MUSE](#), [MyndPlay](#), [NeuroSky](#), [OpenBCI](#)

Low-Latency Tactile Internet

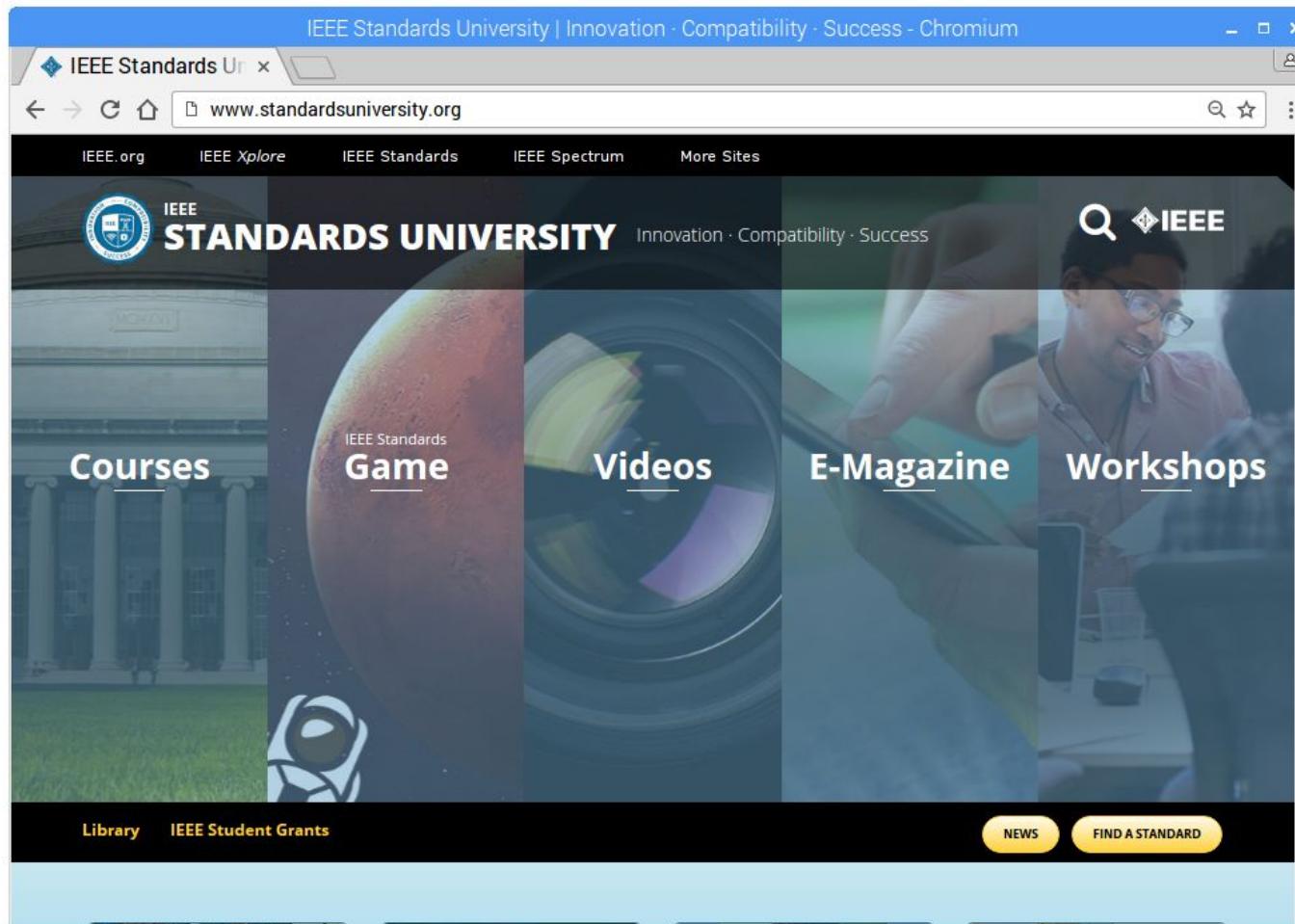
Tactile Internet

- Haptic perception can be kinesthetic or tactile perception
- Example of handshakes with or without wearing gloves
 - Kinesthetic perception can be the same
 - Tactile perception is different
- IEEE P1918.1 Tactile Internet: Application Scenarios, Definitions and Terminology, Architecture, Functions, and Technical Assumptions and P1918.1.1 Haptic Codecs for the Tactile Internet



IEEE Standards University

<http://www.standardsuniversity.org>

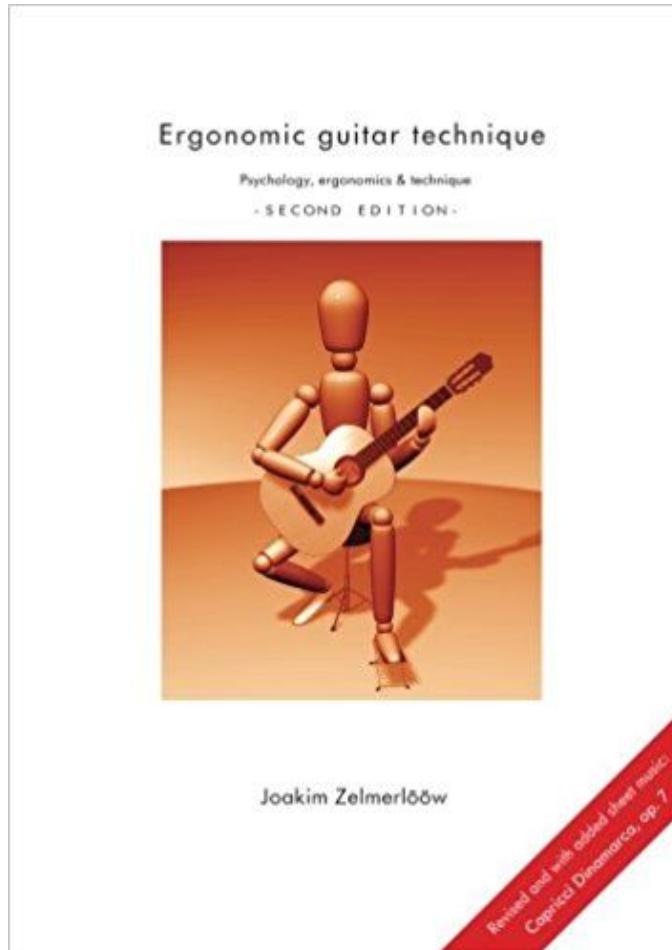


Blockchain and Cryptocurrency

- An anonymous person or group known as [Satoshi Nakamoto](#), satoshin@gmx.com,
 - registered [bitcoin.org](#) on [2008-08-18](#)
 - published "[Bitcoin: A Peer-to-Peer Electronic Cash System](#)" on [2008-10-31](#)
 - mined the [genesis block](#) on [2009-01-03](#)
- A 32-bit golden nonce is a [nonce](#) (number that can only be used once) that results in a hash value lower than the target difficulty and constitutes [proof of work](#) in Bitcoin [mining](#)
- [Hal Finney](#) 1956—2014 was the first person other than Nakamoto himself to use the software ([Bitcoin Core](#)), file bug reports, and make improvements
- On 2010-05-22, [Laszlo Hanyecz](#) (Jacksonville, FL) traded 10,000 bitcoins (about \$41 then) on [freenode IRC](#) with [Jeremy Sturdivant](#) (Santa Cruz, CA) for two pizzas
- Top two [cryptocurrencies](#) [list] by [market capitalization](#) are [Bitcoin \(BTC\)](#) and [Ethereum \(ETH\)](#)
- The value of a [stablecoin](#) (e.g., [Tether](#), [JPM Coin](#)) can be pegged to a currency or to exchange traded commodities such as precious metals to minimize volatility
- Top two [cryptocurrency exchanges](#) are [Binance](#) and [Coinbase](#)

Musical Instrument Ergonomics

<http://flutelab.com/flutelab.com/vertical-flute-headjoint>



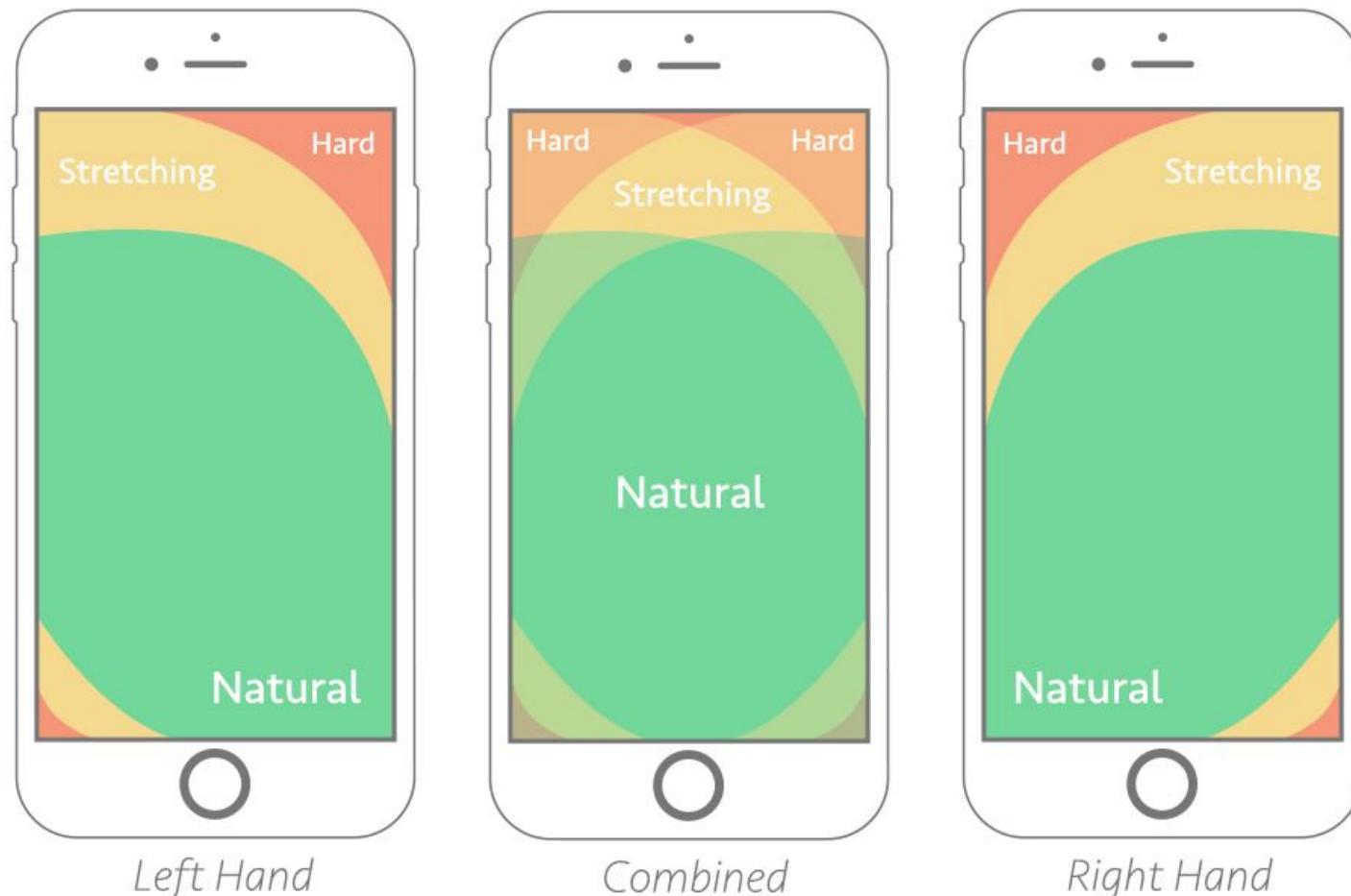
One-Handed Selfie

<https://www.theodysseyonline.com/selfie-generation-hurting-helping>



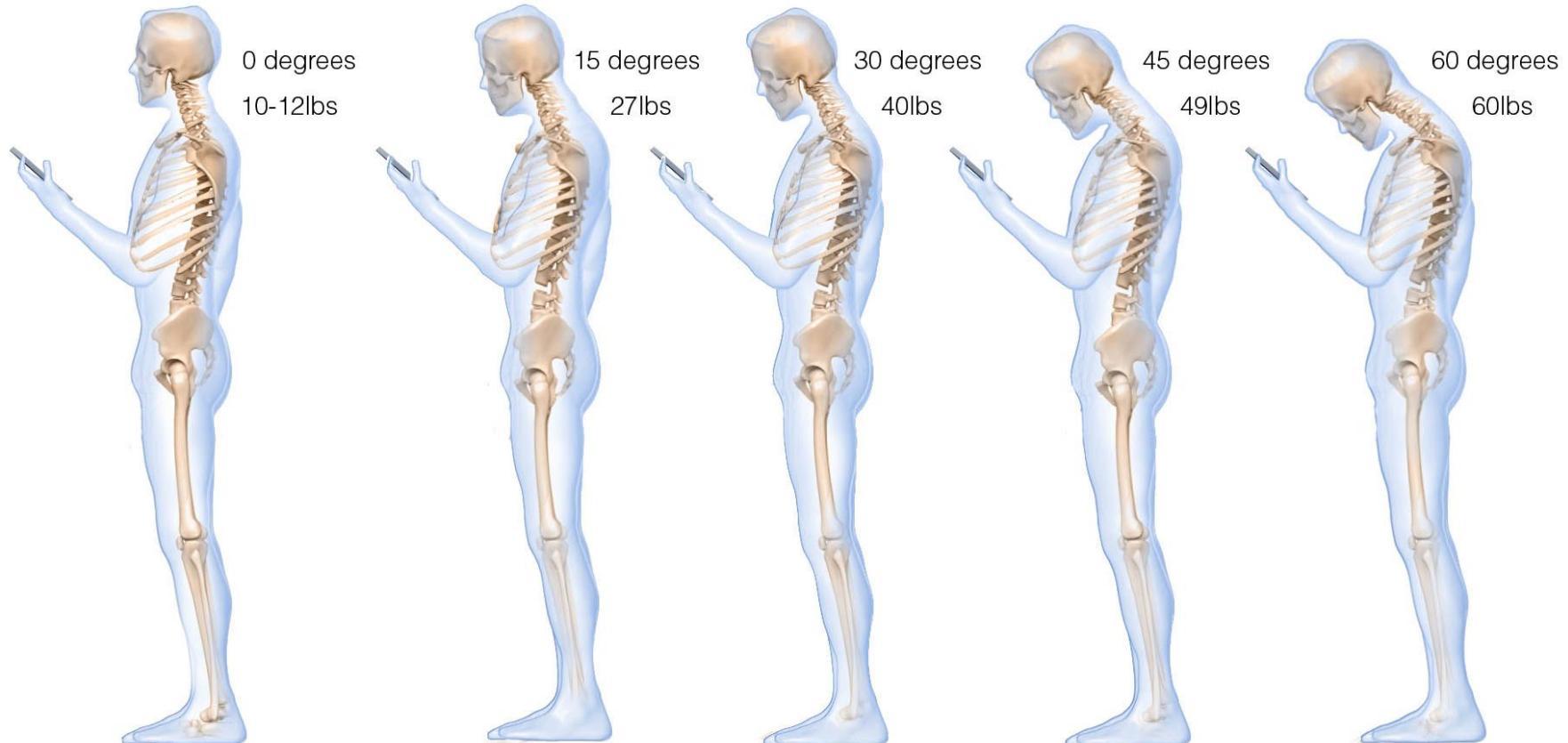
Thumb Zone

<https://www.smashingmagazine.com/2016/09/the-thumb-zone-designing-for-mobile-users>



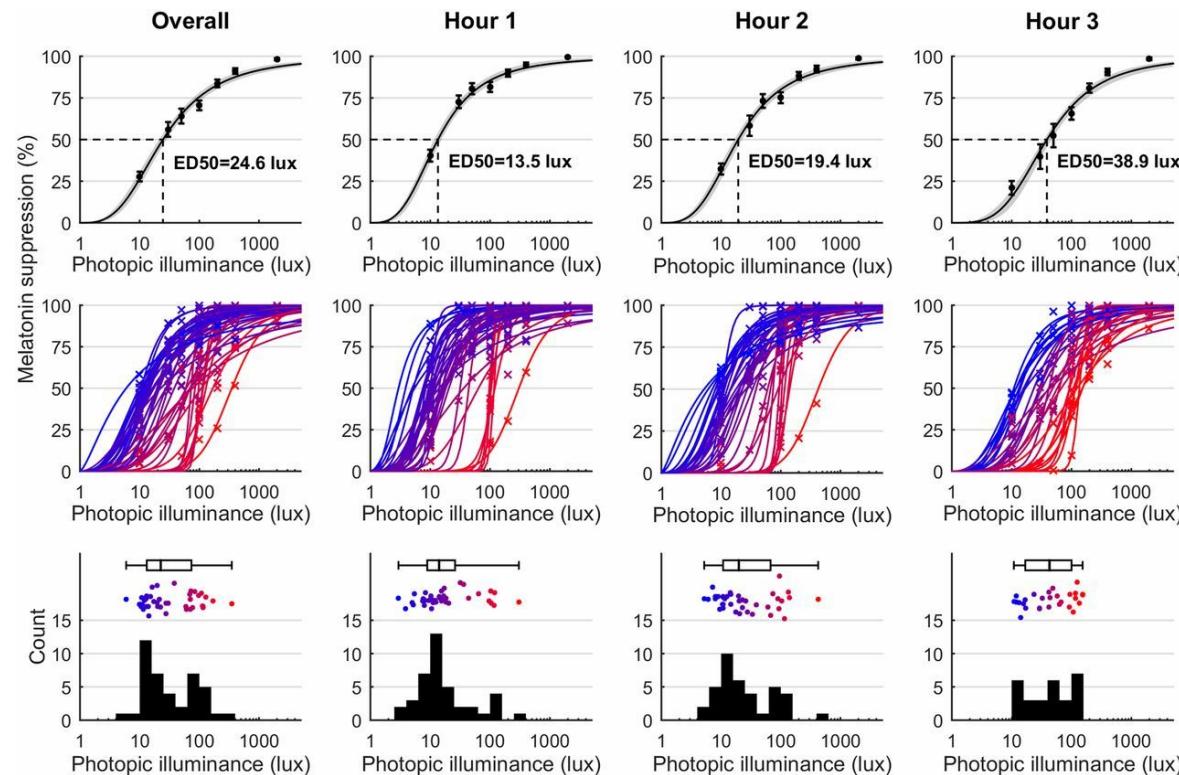
Cervical Spine (Neck) Stresses

Text Neck

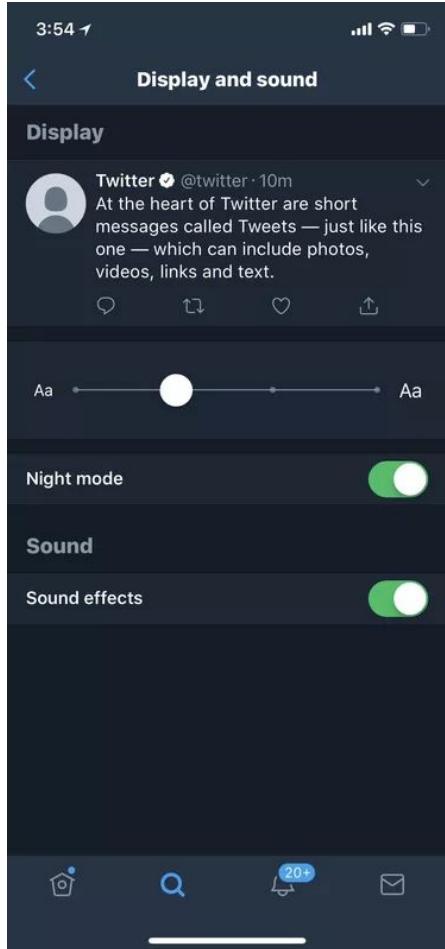


Evening Light Sensitivity

A [PNAS paper](#) shows 50% suppression of [melatonin](#) at <30 lux comparable to or lower than typical indoor lighting used at night and light produced by electronic devices



Dark Mode

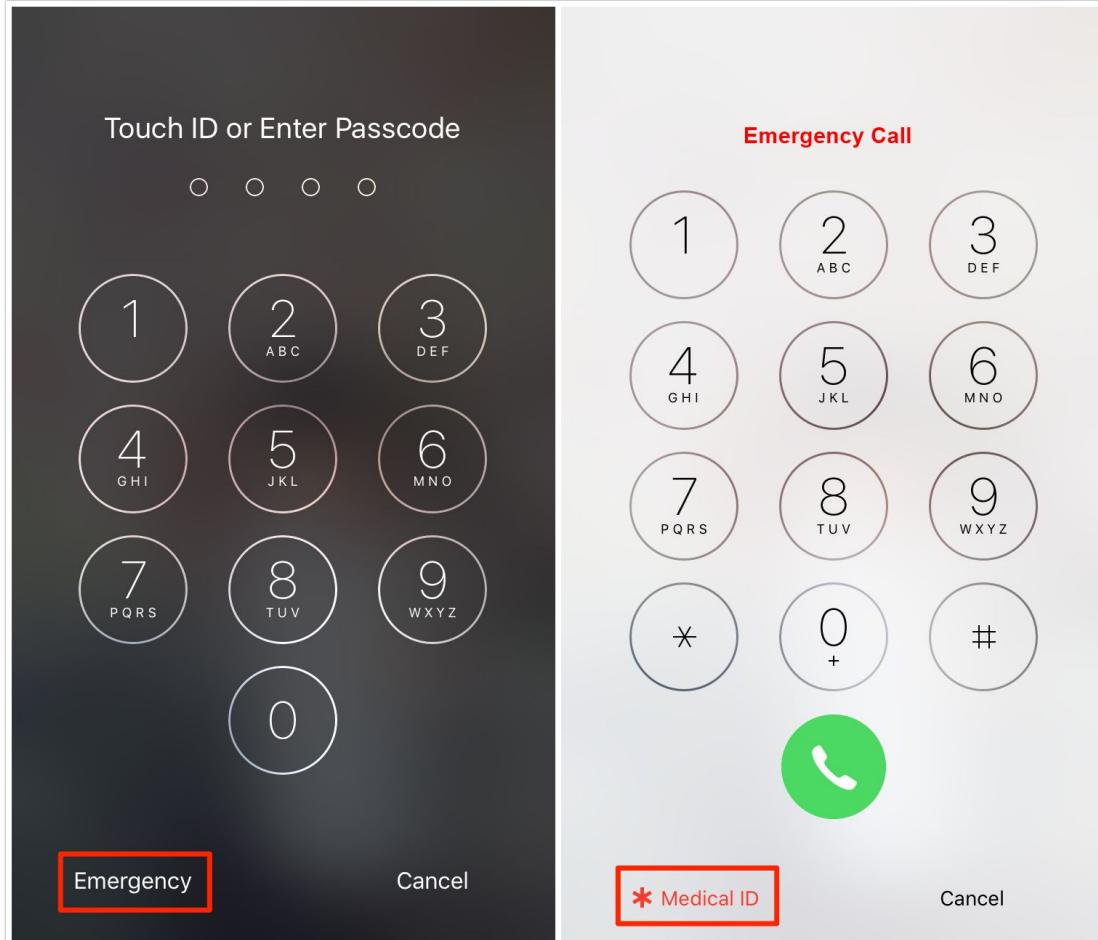


- Light-on-dark color scheme (also called dark mode, dark theme, or night mode) is a color scheme that uses light-colored text, icons, and graphical user interface elements on a dark background
- Twitter was among the first platforms to offer night mode, rolling it out for Android phones in 2016
- Light on dark color schemes require less energy to display on some display technologies, impacting battery life and overall energy conservation

Photosensitive Epilepsy

- [Epilepsy Blocker](#) is a browser extension that blocks flashing [GIFs](#)
- A small portion of the population has [photosensitive epilepsy](#), a condition that may cause them to experience epileptic seizures or have momentary loss of consciousness when viewing certain kinds of flashing lights or patterns that are commonly present in our daily environment
- The persons may experience seizures while watching some kinds of television pictures or playing certain video games
- People who have not had any previous seizures may nonetheless have an undetected epileptic condition
- If experience any of the following symptoms: dizziness, altered vision, eye twitching, involuntary movements, loss of awareness, disorientation, or convulsions, discontinue use immediately and consult a physician

Medical ID



- A Medical ID on [iOS](#) or [Android](#) provides user's name, weight, height, primary language, emergency contacts, or medical information that may be important in an emergency such as allergies and medical conditions
- The Medical ID can be accessed or shared during emergency call from the emergency dialer without unlocking the phone

Doomscrolling

- Doomscrolling and doomsurfing are new terms referring to the tendency to continue to surf or scroll through bad news, even though that news is saddening, disheartening, or depressing
- Many people are finding themselves reading continuously bad news about COVID-19 without the ability to stop or step back

Screen Time Manager

<https://support.apple.com/en-us/HT208982>

